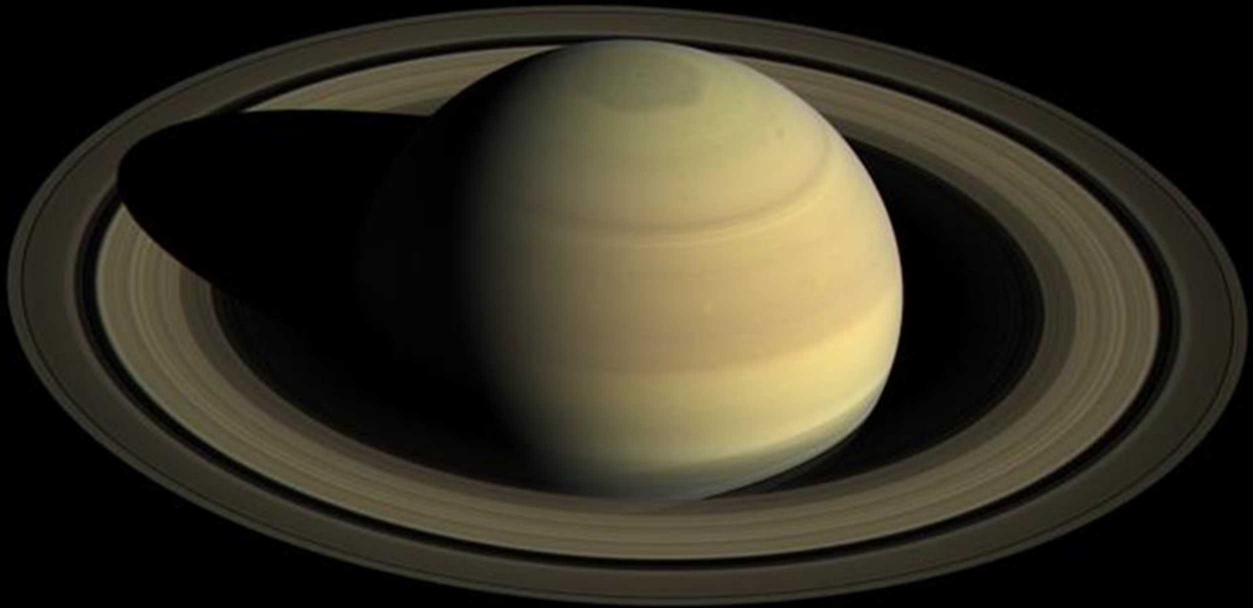

FTIR Instrument design for the Outer Solar System atmospheric studies

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Jet Propulsion Laboratory
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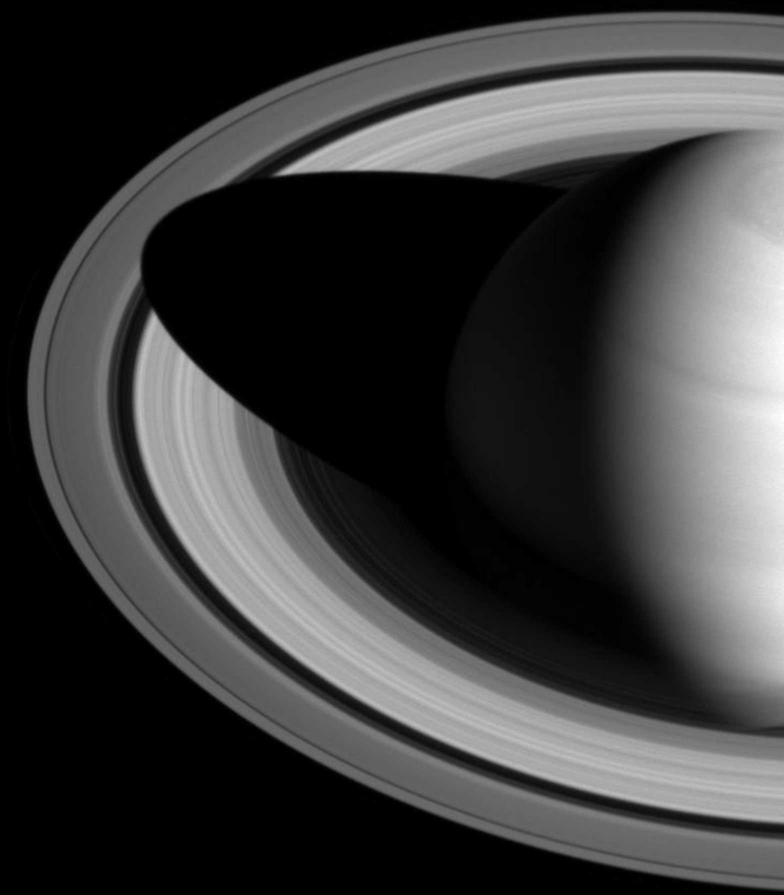
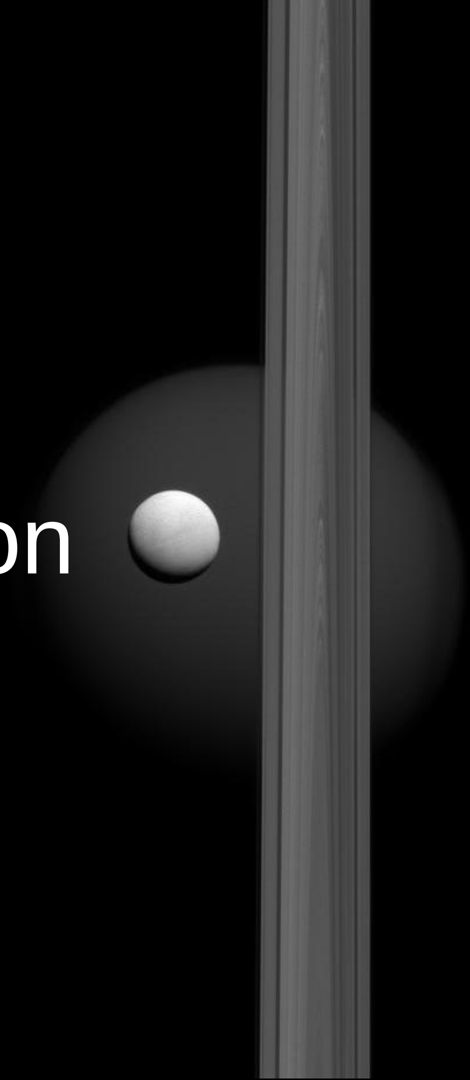


Introduction



I. Introduction

- Nearing end of Cassini mission in Nov 2017
- Need new planetary instrument concept for atmospheric study of giant planets and moons like Uranus, Neptune, Saturn & Titan, and also spectroscopic study of rings and icy moons.

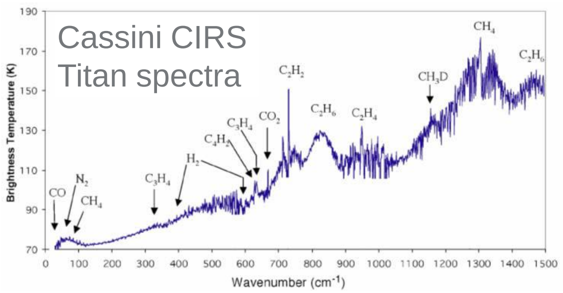
Instrument design trade study

II. Instrument design trade study

Scientific objectives

- Atmospheric study of Gas Giants
- Moons, asteroids, ring particles

Methane cycle, D/H & He/H2 ratios, atmosphere trace constituents (CH4, NH3, PH3…), composition of impurities on icy surfaces, ring particles thermal inertia and composition



A. Coustenis et al.: *The composition of Titan's stratosphere from Cassini/CIRS mid-infrared spectra*, Icarus, Volume 189, Issue 1, July 2007, Pages 35–62

Needed:

- spectral resolution of 0.1cm^{-1}
- spectral range of 100-1400cm^{-1}

Preferred:

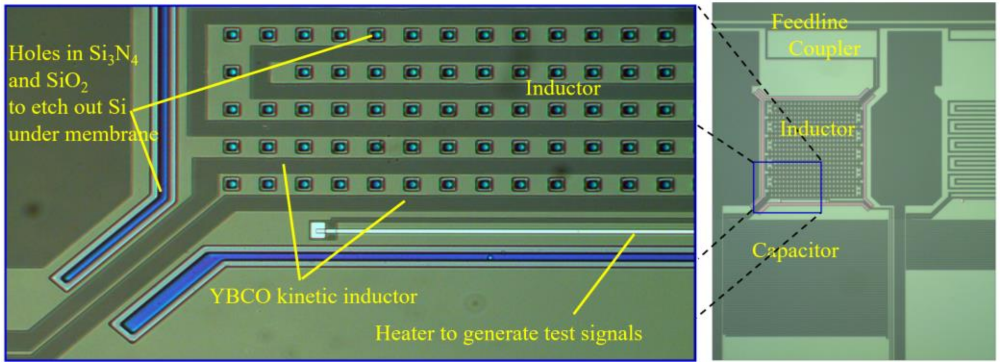
- 2D staring acquisition
- IFOV 1mrad
- spectra acquired within minutes

⇨ Add Spatial & Temporal aspect for atmospheric dynamics

II. Instrument design trade study

Detector technology

- Yttrium barium copper oxide (YBCO) high temperature superconducting kinetic inductance bolometers (KIBs)
  - 2D kilo-pixel arrays
  - Visible to Far IR wavelength range
  - High operation temperature bolometers (55K)
  - High sensitivity



II. Instrument design trade study

Instrument design

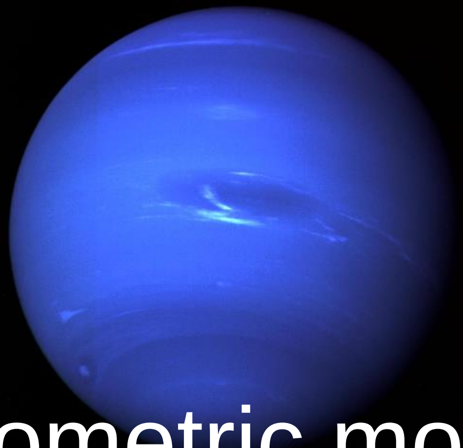
All reflective design:

Grating spectrometer or FTIR?

FTIR Instrument

➡ New generation of Cassini CIRS like instrument

Characteristic	Grating spectrometer	Interferometer
Wavelength range	All-reflective designs possible	Synthetic diamond beamsplitter element
	>3 octaves to cover (low efficiency)	Sampling easier at long wavelengths
Throughput[1]	$A\Omega = \frac{l_{slit} \times A_{grating}}{F \times R}$	$A\Omega = \frac{\pi \times A_{beam}}{R}$ (Jacquinot advantage)
Spectral resolution	Fixed: $\Delta\lambda = 1.6\ \mu m$ for 40×50 pixel array	Tunable with OPD ($\sim {}^{1}/_{\Delta\nu}$)
Mechanisms	None - 2D imaging via scanning the scene (slit) with the spacecraft motion	- Moving mirror for starring design - No moving parts for scanning design



Radiometric modelling and main instrument parameters

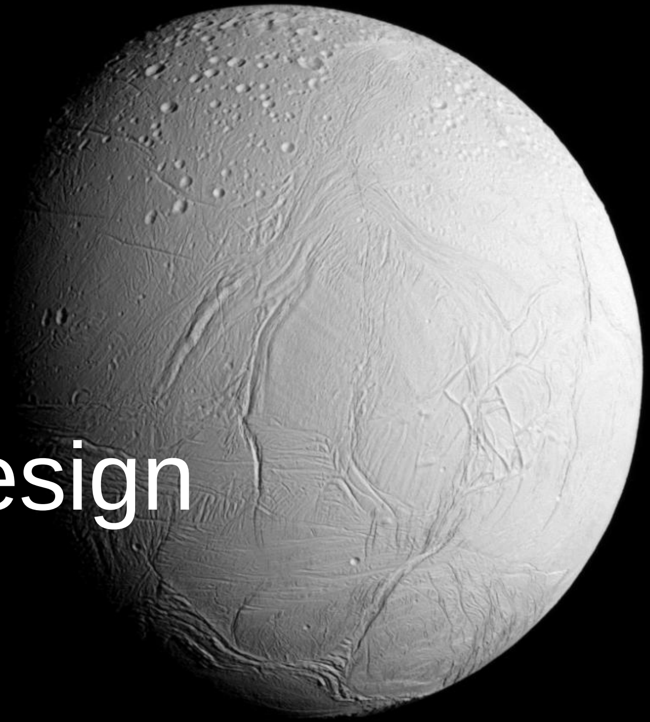
III. Radiometric modelling and main instrument parameters

Radiometric model based on:

- detector performance, (specific detectivity, response time, pixel pitch)
- desired IFOV, (GSD 31km at 31,000km)
- spectral resolution,
- Instrument temperature,
- need for a compact design.

Instrument parameter	Value
IFOV	1 mrad
FOV	2.86x2.29 deg
F-number	11.2
Focal length	1000 mm
Spectral resolution	0.1 cm^{-1}
Wavelength range	100-1400cm-1
Complete spectra acquisition time	200s
Modelled Spectra SNR for 90K scene	2995
Modelled Spectra SNR for 50K scene	170

Optical design



IV. Optical design

Interferometer relay

Full off-axis design for increased throughput

Synthetic diamond beamsplitter : 7 to >100µm

- >10cm OPD using corner cube
- 2 design version of telescope:

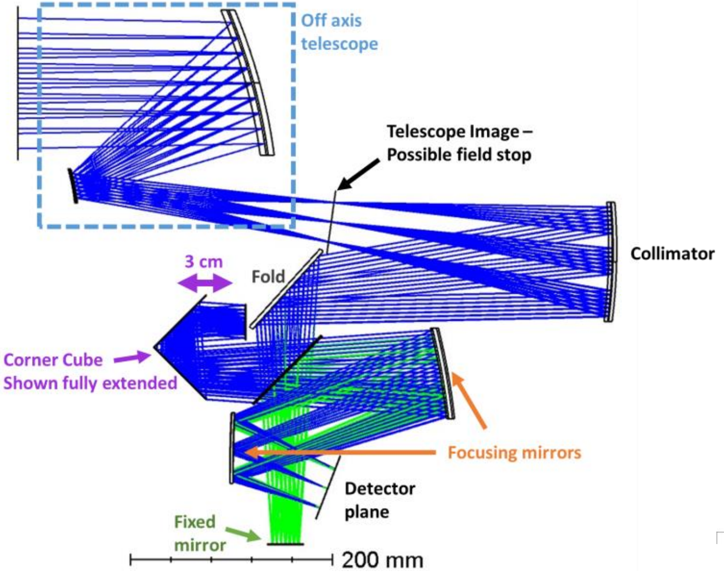
On axis:

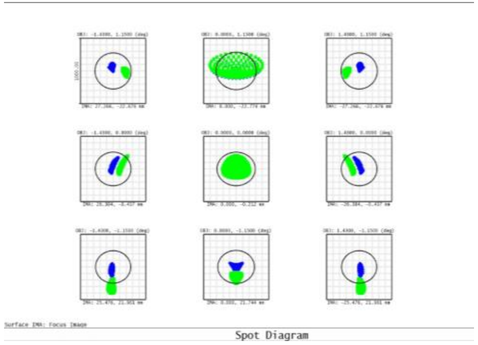
- Optical design volume: 550×405×145mm^3
- Obscuration -8.6%

× 1.44

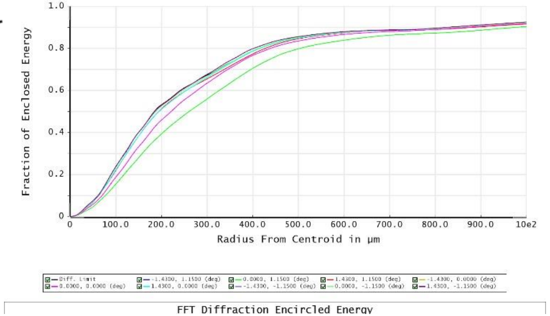
Off-axis:

- Optical design volume: 550×530×160mm^3
- No obscuration





Spot diagram



Fraction of encircled energy

Conclusions

IV. Conclusions

Preliminary Optical design complete but still lots to do:

- Stray light analysis, spectral resolution across FOV analysis
- Passive thermal design modelled,
- New instrument mass, volume, and power estimates in work
- Instrument testbed
- ….

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IV. Optical design

Telescope